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NOTICES OF The Aëronautical Society of Great Britain.

I.—At a Council Meeting of the Aëronautical Society of Great Britain, held at 53, Victoria Street, Westminster, on November 20, 1907, the following gentleman was elected a Member of the Society:—

MR. F. H. PAGE.

II.—The undermentioned gentleman has resigned the position of Hon. Secretary of the Society:—

MR. E. S. BRUCE, M.A., F.R.M.S.,

dated December 22, 1907.

III.—The undermentioned gentleman has been appointed Hon. Secretary of the Society (temp.):—

COL. J. D. FULLERTON, R.E. (ret.), F.R.G.S., F.Z.S.,

dated December 22, 1907.

IV.—In order to ensure the correct delivery of the Journal, Members are requested to notify the Hon. Secretary as early as possible of any change in their address.

V.—Cheques and Postal Orders for annual subscriptions, etc., should be made payable to

The Hon. Secretary,
The Aëronautical Society
of Great Britain,

and crossed "Coutts & Co."

VI.—Members desirous of obtaining a grant from the "Research Fund" (Mercer's Grant) are requested to forward applications for the same not later than February 15, 1908.

The applications should be accompanied by a brief statement, explaining clearly how it is proposed to expend any sums granted.

The Starting Methods of Aëroplanes.

By JOSÉ WEISS.

The heaviest flying birds known scarcely reach one quarter of the weight of an average man, and it can be said that one of the most probable causes of the absence in Nature of heavier varieties is the fact that although such birds could fly easily enough, once on the wing, they would be unable to leave the ground, owing to the enormity of the power the first lift would require. The larger and heavier the bird, the less, in relation to its weight, is the power developed in flight, but, on the other hand, the greater is the effort needed for a lift from the ground. I do not wish to enlarge upon this question, which has been treated by various authors, and only refer to it because it embodies a principle which we must bear in mind when considering the means of starting flight, namely, that the

difference between the power required respectively for the flight and for the start becomes greater as the apparatus increases in weight.

It is for this reason that many workers in the problem of flight have been trying to evolve a suitable device for effecting a start, and many suggestions have been made from time to time. No one anticipated the magnificent results obtained recently in France, and from which it is now perfectly clear that it is possible, with the present-day light motors, to raise an aëroplane by its own means straight from the ground.

But are we to conclude from these results that the problem of the start is one that can be considered as finally solved from a practical point of view?

Being given a large open area with a level and smooth surface, a machine, fitted with a motive power much in excess of what it really requires for actual flight, can be run like a motor car, nose to the wind, until such speed is reached that will lift it from the ground. Nothing seems simpler, and we say, therefore, that such a machine is capable of starting unassisted from practically anywhere. The fallacy, however, of such a conclusion soon becomes evident, when we realise how very rare are the spots which will combine all the required conditions. The world is made of fields, either ploughed or covered with crops, and cut up by ditches, hedges, and trees. Towns, villages, and roads are out of the question, and, on the average meadow or turf covered down, it would be impossible to get up the necessary speed without considerable risk of smashing wheels and springs. In fact, the spot required is one, not being a road, on which it would be possible to run a motor car at full speed in any direction. Such places are very uncommon. Mr. Roe will excuse me quoting his case as a typical one. His machine is of the type which is supposed to raise itself from anywhere. But I understand that he had great difficulty in finding a place suitable for his purpose.

Like any other means of conveyance, the aëroplane has its possibilities and its limitations. Railways are not useless because they cannot land us at our door, nor is the motor car dwarfed because it cannot take us over hedges and ditches like a good hunter. Even our old friend the balloon, which can ascend in a vertical line, can only do so in the proximity of gas-works. By its very nature the aëroplane will always require plenty of space both to start and to land. However perfect we manage to make it eventually, it will always be a more or less cumbersome affair. Its housing alone suggests the necessity of specially adapted stations or garages, far away from street traffic and telephone wires. It is not likely that we shall ever use an aëroplane to go from the Bank to Charing Cross, unless the stations of this future penny fare are built high above the house tops. There is no doubt, however, that if the aëroplane is not likely to ever be a convenience for short distances, for long cross-country or over-sea journeys it is bound to be, before long, the ideal mode of travelling, for swiftness, for economy, for comfort, and for safety. But, then, it shall be mostly required to take us from one town to another, or to its immediate vicinity. Streets and public squares are obviously out of the question for a landing, and the rest of the land near towns is very generally private residential property and, therefore, unavailable.

Imagine yourself possessed of a perfect aëroplane capable of taking you to your intended destination, Manchester, for instance. In the present state of affairs what will you do for a landing when you get there?

We are apt to be misled by a sort of unconscious comparison in our minds between the newly-arrived motor car and the coming aëroplane. The element of the motor car is the street and the road, but these are as useless to the aëroplane as they are to a steamboat. We have to deal here with a new element which demands organised conditions hitherto uncalled for. In the same way as a ship can only take us to the port nearest to our destination, so an aëroplane will only land us at places suitable for landing and for re-starting, and where accommodation will be found for leaving our machines whilst we go to our business.

The terror which the ubiquitous flyer would soon become in the hands of evil-doers or of inexperienced operators will make special legislation at once imperative. From this point of view alone it is obvious that the possibility of a supervision by the law for the prevention of crime and of accidents can hardly be conceived unless the starting and landing of flyers are impossible at any but pre-arranged points or stations. On this score, however, the public has a solace in remembering that with-

out broad daylight or, at least, powerful artificial light, landing, or even approaching the ground, will never be possible, and that, therefore, misdeeds of aërial burglars under cover of darkness need never be feared.

Accepting it, therefore, as a fact that stations will be a matter not of choice but of necessity, it remains to examine what is the most expedient and inexpensive way of providing and of multiplying these stations all over the country.

We have seen that to start an aëroplane straight from the ground is a method most wasteful as far as power goes. It is safe to say that, for such a start, a machine must carry a motor of a power at least double that which it really requires for level flight or for a slow ascending gradient. But this is, perhaps, not the main drawback; the greatest objection is the extent and the quality of the ground which this mode of launching requires. An aëroplane derives its lift from speed and from speed alone, and, what is more, it is the speed not in relation to the ground, but the speed in relation to the surrounding air. Supposing there is a wind of 20 miles an hour and the speed necessary to obtain a lift for your machine is 30 miles, if you run your machine with the wind you will have to run it at the rate of 50 miles on the ground before you can raise it. If, on the other hand, under the same conditions of wind you run your machine against the wind, a speed of 10 miles on the ground will be sufficient to give you a lift. Hence the necessity of having a ground on which you can run your machine in any direction, against the wind, whatever point of the compass it may be blowing from at the time. For this I should say that an area of level and hard surface of 200 yards in length and in breadth, that is, about 10 acres, is the minimum that would have to be allowed. The cost of acquiring or hiring, and of levelling and preparing such places would be very great.

In the last two years I have tried about a dozen different methods of automatic launching, the most successful being a pole having at its top a cross-bar from which two parallel hawsers ran into the ground to a distance of about three times the height of the pole. The pole was mounted on a pivot and surmounted by a weathercock, so that the hawsers could always be fixed in the correct position facing the wind. The machine to be launched was placed on a cradle which itself was fitted with grooved wheels running on the hawsers. The initial thrusts was obtained by means of a weight and a system of block pulleys fixed on the pole. This gave excellent results, and I succeeded in launching models weighing over 60 lbs. repeatedly, without a hitch, in calm and in rough weather. The difficulty, however, of stretching the hawsers sufficiently and equally tight, and the time lost in constantly changing their position with each variation in the direction of the wind, proved to be a great drawback and a possible source of danger if the system was to be used for a man-carrying machine.

The lesson taught by these experiments has led me to the design which I am advocating now, and which has all the advantages of the pole and hawsers without the drawbacks.

The drawings give the general lines of these launching ways. It is a rigid structure made of light steel joists and resting on a pivot; it is steadied by four rollers running on a circular rail placed on the ground. At the top is a small platform reached by means of a ladder. The floor runs from that platform and has at its lower end, and hinged on to it, a short prolongation, kept away from the ground by a balance weight. This prolongation is there merely to land the machine safely on the ground if no start is obtained. The cradle is dispensed with and the aëroplane is run down the floor on its own wheels. The initial thrust (if any is required) is obtained by a weight made up of moveable cast-iron discs and by means of a very simple system of ropes and pulleys. The aëroplane to be launched is brought to the foot of the ways and hauled up backwards by means of a windlass, and whilst it is being hauled up, the impelling rope is attached to it by means of a special catch, so made that as soon as the least lift is produced, the machine is released automatically and the start is effected.

For brevity's sake I cannot enter here into more detail, but shall be pleased to give full information to persons interested, and also to show them the example of these launching ways which is in course of erection on the downs near Arundel, and will be completed very shortly.

The advantages I claim for these launching ways are the following: —

1. They are inexpensive as compared with the cost of levelling and pre-

paring a large area of ground. They can be erected in any field or meadow having a length of from 80 yards to 100 yards both ways (that is less than two acres in area), as long as the field or meadow is not bordered by high trees or buildings.

2. By using them, the motive power with which a machine would otherwise have to be fitted can be reduced to the minimum required for actual flight.

3. Once built, the ways are always ready for immediate use, in all conditions of wind and for all types of machines, and there are no parts liable to get out of order.

4. The initial thrust, being obtained from a weight, is gradual and quite free from jerk. The weight can be increased or reduced at will to suit machines of any dimension, while insuring the certainty of a start.

5. There is total absence of danger, the launching floor actually touching the ground; the machine which, for some cause or other, fails to start, simply runs on to the ground below.

6. The whole structure resting on a pivot can easily be kept true to the wind during the process of launching, thus rendering dangerous side gusts impossible. By being fitted with a fan-tail similar to those used in windmills the ways are kept true to the wind automatically.

7. This method of launching enables the experimenter to obtain short glides in calm weather, without motive power, giving him thus an opportunity to test his machine with a minimum of danger, and to acquire the reflex movements so essential for balancing and for landing.

8. For war purposes, where an army can never be certain of finding a suitable spot for launching their machines by running them on the level ground, launching ways as these can easily be made in collapsible sections. The whole concern, weighing scarcely a couple of tons, can be packed on waggons and rigged up ready for action, or taken down by a squad of trained men in less than half-an-hour.

If the Aëro Club could be induced to erect such launching ways at Brooklands or elsewhere there is little doubt but that they would prove of great use and that they would soon be followed by others at different places. These could be surmounted by a distinctive flag, discernible at long range, and experimenters would then have a chance of at last taking a real journey from one place to another, where they would find all that is essential for landing and for re-starting. Observe that no one so far has ever attempted to leave his operating ground. The unanswerable query stands in the way: Where shall I land and re-start from?

A Study of Model Gliders.

By A. V. Roe.

The fact that a considerable amount of knowledge can be gained by experiments with weighted model gliders does not at present appear to be sufficiently appreciated; only with model gliders, for convenience sake, a less weight is used per square foot of carrying aëroplane surface. A $\frac{1}{4}$ lb. per square foot area is a convenient demonstrating weight, giving a speed of about 8 m.p.h., with a drop of about one in six; with man-carrying machines the usual weight varies between $\frac{1}{2}$ and $1\frac{1}{2}$ lbs.

If a single aëroplane be released in the air it will simply fall anyhow to the ground, but on fixing a steering plane fore or aft, let us say in front as in Fig. 1, there will be a tendency for it to glide, but sooner or later one side will dip downwards, owing to the two planes not being in the same straight line or being improperly balanced. If the left side dips the whole will turn to the left and gradually fall in towards the centre of the circumference it is describing. If, instead of the single posterior, two superimposed planes are substituted, the same phenomena will be observed. Now, if one or more vertical planes are fixed between the superimposed planes, it will be found the falling-in tendency no longer exists, but the model will not glide satisfactorily for any distance. If the anterior plane is fixed with a slightly upward angle relatively to the main planes, the forward movement is quickly checked, owing to the air pressure

FIG. 1.

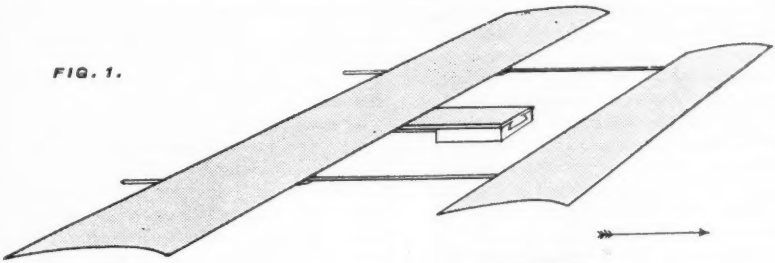


FIG. 2.

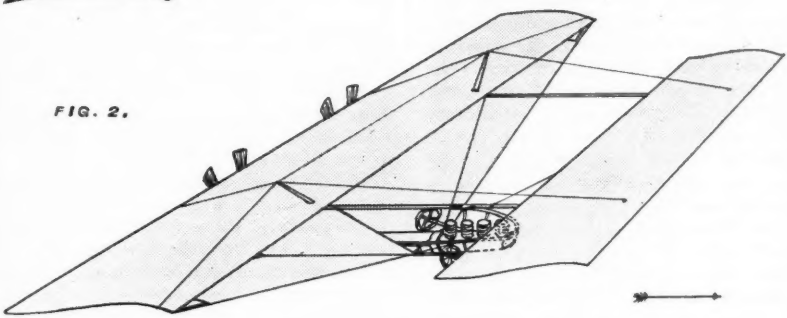
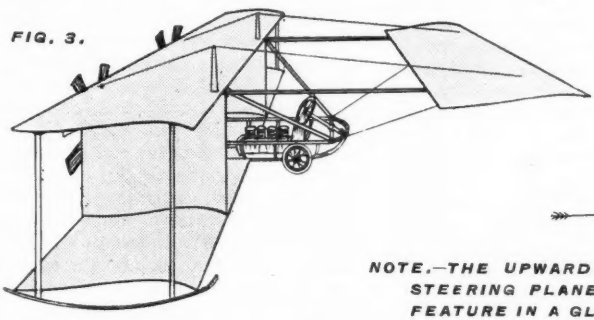
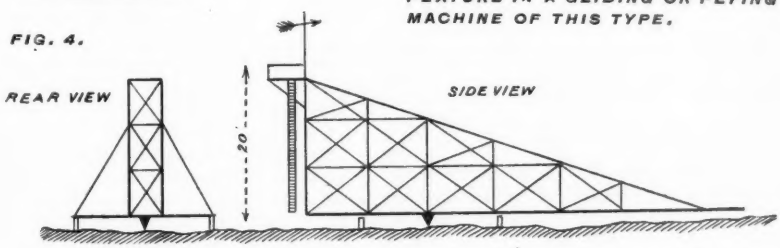


FIG. 3.



NOTE.—THE UPWARD ANGLE OF THE STEERING PLANE, AN ESSENTIAL FEATURE IN A GLIDING OR FLYING MACHINE OF THIS TYPE.

FIG. 4.



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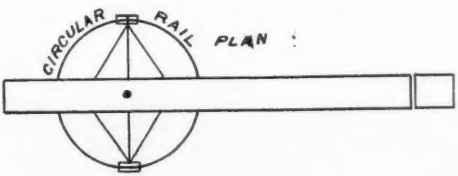

forcing upwards the front plane and, consequently, the whole model. In order to counteract this lifting-up tendency the centre of gravity is brought more forward until a suitable position can be determined, when it will be found to make a straight glide at a definite speed. If the centre of gravity is not brought sufficiently forward the model will take an upward course, the speed being thereby reduced until the pressure on the forward plane is not sufficient to keep it up. The result is the speed is accelerated, the model once again takes an upward course, and the whole series of switchback glides is repeated until the ground is reached. If there is any secret in flying it is this upward angle, for without it there is no stability. See Fig. 3.

There are several ways of steering the machine laterally; vertical planes fore or aft may be used for this purpose, but they have their disadvantages, and if forward a side puff is apt to blow the machine from its course; also a vertical plane is naturally flat, causing eddies when used for steering. Seeing that simplicity is a great object with a gliding machine and both lateral and vertical control may be obtained entirely with a horizontal steering plane, with a minimum disturbance of the air, it is hardly advisable under these circumstances to complicate matters by having more planes than absolutely necessary. When so fitted lateral steering is effected by raising one side of the steering plane higher than the other; for instance, if the right side be raised, the whole machine turns to the left.

If the horizontal steering plane be fitted at the rear the centre of gravity still remains forward, but the tail requires to be turned up at the posterior edge, giving the glider an upward tendency as in the case of the forward steering plane. The disadvantage of this type is that the air acts on the upper surface pressing the tail downwards; consequently it does not act as a supporting surface, but otherwise.

The proportions of a satisfactory model are as follows:—Width of main aëroplane $\frac{1}{6}$ of the tip-to-tip measurement, steering plane $\frac{2}{3}$ tip-to-tip and about $\frac{3}{4}$ the width, fore and aft measurement being about $\frac{1}{2}$ the tip-to-tip of main aëroplane. Of course, these are approximate and can be varied. For instance, the larger the steering plane the nearer it may come to the main aëroplane, and for even speeds the pressure per square foot appears to remain constant on various-sized and positioned steering planes, for when the latter is increased in size the centre of gravity is brought more forward, and likewise if it is brought nearer the main plane, so the centre of gravity is moved back.

By constructing the main aëroplane so as to take various sized steering planes and adding or subtracting the weight so as to keep the average of $\frac{1}{4}$ lb. per square foot, then some very interesting experiments may be tried. A good method of testing their respective merits is to drop the model head downwards from a certain point and note which combination gives the best results.

On experimenting with a glider weighted to $\frac{1}{4}$ lb. per square foot and dropped head downwards (not thrown) from a height of 7 feet it will be found to swerve down within two or three feet from the ground about three feet in advance of the starting point, by which time it will have assumed a horizontal position, skimming along, and finally landing 20 feet from the starting point. By this means many and various modifications may be tried and compared.

A question that will naturally be asked is "How is a sudden diving tendency to be avoided?" The planes can be so arranged that this will be impossible, so long as the machine retains its rigidity, for the steering is so set that it cannot be turned beyond a certain point, this point being the least advisable uplifting angle.

One often hears the remark that Nature is the best guide to the solution of this problem. The albatross, a bird living in windy regions and a wonderfully efficient glider with a 12 to 15 feet tip-to-tip measurement and a wing depth not exceeding $8\frac{1}{2}$ ins. at the widest part, may be taken as our model. But, however skilfully a gliding machine may be made to imitate this or any bird, it will have no stability. Why this should be so is not far to seek. The albatross instinctively balances itself, the tail being too small to be of any real value for steering. In the same way a cyclist instinctively balances while cycling, the movement of his handlebars being hardly perceptible if he so wishes, whereas if one of the most life-like models of Madame Tussaud's be sent on a cycle journey it would be of short duration. All this points to the necessity of having some controlling arrangement that will always keep the main aëroplane or planes gliding on the air, with no undue risks of suddenly diving. Gliding models made after the style shown in Figs. 2 and 3 are perfectly stable while in mid-air.

Fig. 2 is a rigid triangular form of main body, the advantage of which is that the tips of the aëroplane are well clear of the ground.

The object of showing Fig. 3 is more particularly to point out the upward angle of the steering plane relatively to the main aëroplanes, without which there is no stability.

So with our present knowledge and engines at our disposal it appears quite feasible to construct a machine that will take to the air and be under complete control, and this with no undue risks to the aviator, provided the machine is rigidly and well built.

Mechanical Aërial Navigation.

By Rankin Kennedy.

This paper is intended in the first place to ascertain some definite and tangible ideas as to dimensions of the vital parts of machines "heavier than air" designed for aërial navigation. The vital parts are, of course, the engine and propeller.

In the second place it is proposed to discuss the aëroplane and its functions in an airship.

In all engineering problems the first requisite towards a solution is to reduce things to numerical values. An inventor may imagine a design for a machine, but he cannot put it into practice without calculating out the necessary dimensions, and such calculations, when undertaken, often either confirm or condemn the design.

Much of the experimenting at present going on is evidently entered upon, and carried on, without any calculations at all, the only results being a waste of time and money.

In the sciences of Hydrostatics and Mechanics and in the practice of Marine Navigation we have stored up data, laws, and rules, all of which are applicable when modified, for the differences between a gaseous and a liquid fluid, to the solution of the engine and propeller dimensional problems.

It is proposed to treat the power and propeller questions first without reference to aëroplanes or any other secondary device which does not contribute to the power or work of overcoming gravity and air resistance.

We have two forces to provide in the airship—first, a force constant in direction and amount, to sustain the weight of the airship in the air, and second, a force variable in direction and amount to propel the ship against the resistance of the air.

Without going into a mathematical demonstration here, to prove the statement, it may be accepted that when two forces are required, one constant and the other variable, it is much better to provide for them and deal with them separately.

In this paper we shall, therefore, calculate out the dimensions for sustaining the airship in air regardless of propulsion, and then calculate dimensions for propulsion alone.

Only the screw propeller is to be considered, as mechanical wings are considered by the author impracticable.

Any propeller whatever working in a fluid produces a thrust T by the reaction of the weight of fluid W acted upon and impressed with a speed S per second. And to reduce T to pounds of thrust or pressure we employ the factor of gravity $g = 32.2$, and the formula becomes

$$T = \frac{WS}{g} \qquad (1)$$

and by transposition we get

$$S = \frac{T \times g}{W} \text{ and } W = \frac{T \times g}{S} \qquad (2)$$

In this paper g will be taken as 32 to simplify.

To sustain a pound weight in air, by a propeller, evidently requires a thrust T of a propeller = 1 lb. Hence we can find what value S should be when T = 1 and W = 1 we get

$$S = \frac{1 \times 32}{1} = 32 \text{ feet per second.} \qquad (3)$$

as the speed, S, to be imparted to the fluid per second by the propeller, but we could make W less or more and still get the same thrust T.

Thus if W = 4 lbs., then we would get in this case

$$S = \frac{1 \times 32}{4} = 8 \text{ feet per second}$$

as the speed of air sent astern by a propeller to sustain one pound in air.

The energy or work done in sustaining the one pound weight is equal to, in foot lbs. per second,

$$FP = \frac{WS^2}{2g} \qquad (4)$$

Hence a very important fact, which must

never be overlooked or neglected, and that is, that we may increase T by either increasing W or S or both, but an increase of S demands more power in proportion to the square of S, while it is only directly proportional to W. For instance, in the first case

T = 1. S = 32. W = 1, hence

$$FP = \frac{1 \times 32 \times 32}{64} = 16 \text{ foot lbs. per second,}$$

and in the second case

T = 1. S = 8. W = 4 we get

$$FP = \frac{4 \times 8 \times 8}{64} = 4 \text{ foot lbs. per second (5)}$$

For the same thrust the work required in the latter case is four times that required in the former case.

That is to say, the energy required to lift a pound weight in air by a propeller is not a fixed quantity, but depends on S and W, and hence if W = 16 lbs. and S = 2 feet per second, then

$$FP = \frac{16 \times 2 \times 2}{64} = 1 \text{ foot lb. per second.}$$

One foot lb. of energy per second would lift 1 lb. of weight against gravity.

In the first case the weight lifted would be 34 lbs. per horse-power, in the second 137 lbs., and in the third 550 lbs. per horse-power, from which it will be seen that there is in theory no fixed limit to the weight lifted per horse-power expended.

But in practice there is a limit and a very small value of a limit.

The area A of the propeller disc increases as W is increased, and soon becomes unmanageably large.

And secondly, the waste of power becomes prohibitive when S increases. The question arises as to how to apportion the relative weights of engine and propeller; in the first case the engine would be 16 times the power of the engine required in the third case, but the area of the propellers would be in the inverse ratio. The engineer must in such a case very carefully consider the question and make a judicious compromise between the two conditions.

To get even the thrust of 137 lbs. per horse-power means a very large value for W, and, what is the same thing, diameter of propeller, as we shall see.

We shall use the following constants and symbols throughout:—

0.08 = Weight of one cubic foot of air.

32 = Gravity g.

A = Area of column of air or propeller disc.

S = Speed of column of air in seconds acted upon by propeller.

s = Speed of propeller, *i.e.*, its pitch multiplied by its revolutions per second, and

V = Speed of airship.

W = Weight of air in lbs. per second acted upon by the propeller.

T = The thrust produced $T = \frac{WS}{G}$

F.P. Foot lbs. of energy expended per second.

H.P. Horse-power 550 × F.P.

P.R. = S = Pitch multiplied by revolutions of screw.

Now we can consider the question of area A of air column for a lift of one pound, and so get an idea as to propeller diameters. A column of air of, say, one square foot area in section driven off at 16 feet per second would evidently carry $S \times A = 16 \times 1 = 16$ cubic feet per second; the weight W per second would then be $= 16 \times .08 = 1.28$ lbs. The reaction or lifting power would be

$$T = \frac{WS}{g} = \frac{1.28 \times 16}{32} = 0.64 \text{ lb. lifted.}$$

Now we could get the same lift from a propeller of one-fourth the size by increasing S by twice, thus

$W = A \times 0.08 \times S = 0.25 \times 0.08 \times 32 =$ 0.64 and $T = \frac{W \times g}{S} = \frac{0.64 \times 32}{33} = 0.64$ lb. lifted, same as before.

But in the first case we have a propeller of 144 square inches area driving the air at 16 feet, in the second case we have a propeller of 36 square inches area driving the air at 32 feet per second, both lifting the same weight.

But let us count the costs in power:

$$FP = \frac{WS^2}{64} = \text{1st case} = \frac{1.28 \times 16 \times 16}{64}$$

$= 5.12$ foot lbs.

$$\text{In the 2nd case} = \frac{0.64 \times 32 \times 32}{64}$$

$= 10.24$ foot lbs.,

showing the smaller propeller taking twice the power for the same lift.

These experiments on paper are very instructive. If we use small propellers we must sacrifice engine power; in the above case by reducing the propeller to one-fourth we throw away half the power exerted. The power, instead of supporting the weight, is expended in increasing the air column's velocity astern only.

Now let us consider the size of a propeller to support 1,000 lbs. in air with a value of S = 16 feet per second. First find the weight W of air required. It is equal to

$W = \frac{T \times g}{S}$. We have T = 1,000. g = 32. S = 16, hence $W = \frac{1{,}000 \times 32}{16} = 2\,000$ lbs. of air per second. (7).

The cubic feet in this weight would be = $\frac{2{,}000}{.08} = 25{,}000$ cubic feet, and this, at 16 feet per second, equals an area of $\frac{25{,}000}{16} = 1{,}560$ square feet—giving a propeller of great size, nearly 44 feet in diameter for the lifting propeller.

If S were increased to 32 feet per second, W would be equal to $\frac{1{,}000 \times 32}{32} = 1{,}000$ lbs., and the cubic feet, 12,500, which, divided by the velocity = 32, equals 390 square feet area of propeller, or 22 feet diameter.

But in the first case the horse-power expended on the air would be =

$$HP = \frac{\frac{WS^2}{2g}}{550} = 14.5$$

and in the second case 29-horse power would be required.

These worked-out examples of calculations show clearly the limits to sizes of propellers for lifting; they, in their work, are practically working against a fixed body, *i.e.*, the airship at a constant level above the earth. As propellers they are only sustaining weight, and their efficiency is simply dependent upon the value of S.

The horse-powers calculated by these formulæ is the actual horse-power at the propeller blades; the horse-power at the engine would probably be double or more to make up for frictional losses.

To consider now the propulsion of the airship. In the foregoing we have simply considered its support against gravity, and seen that propellers for that purpose must of necessity be large, owing to the small weight of air per cubic foot. In propulsion we have to overcome the resistance R of the air only, and that is small if the airship is properly shaped. It, however, increases as V^2 the velocity of the ship.

Now since R = T and both = $\frac{WS}{g}$, and W equals A × S × .08, we might write instead of $\frac{WS}{g} = \frac{A \times S \times .08 \times S}{32}$ or $AS^2 .08 = R$ or T when the propeller is a support only.

But when the ship is in motion we have the power divided into two components, one moving the ship ahead at velocity V, and the other moving the air astern at velocity S.

We will assume that the speed of the ship V is equal to the speed of the air moving astern, at which speeds the efficiency of the propeller is $\frac{V}{\frac{V+S}{2}}$

giving an efficiency of 66 per cent. for the propeller.

$$\text{Now } T = \frac{.80 \times A\,(V + S)\,S}{32} \quad (8)$$

and R equals the same.

$A = \frac{32 \times R \text{ or } T}{.08\,(V + S)\,S}$ the area of propeller; V and S are in feet per second. Assume V = 17 feet and S = 17 feet (that is, 10 knots per hour), and R = 100 lbs., we get $\frac{32 \times 100}{.08\,(17 + 17)\,17} = 70$ square feet of propeller area required or 9½ feet diameter for propulsion.

The horse-power required is equal to

$$\frac{R \times V + \frac{WS^2}{2g}}{550} = \frac{100 \times 17 + \frac{95 \times 17^2}{64}}{550}$$

= 4-horse power nearly, probably 10-horse power actually, at the engine.

The resistance of air to a surface depends upon its shape, and we have no experience to guide us to actual values; and experiments in tow rope resistance are required to ascertain values for resistance at various speeds and with different shapes.

There is no doubt we shall have to do for airships as had to be done for steamboats, *i.e.*, calculate out the horse-power from a constant C found by actual experiment.

In marine propulsion the formulæ is

$$HP = \frac{V^3 D^{\frac{2}{3}}}{C} \text{ and } C = \frac{V^3 D^{\frac{2}{3}}}{HP} \quad (9)$$

to indicate the performance.

V = Velocity.

D = Weight of ship.

C = Experimentally found constant.

The resistance in air is very much less than in water, so that even 100 lbs. thrust is likely to propel an airship at a high velocity.

The higher the velocity of the ship the better, within certain limits; for the slip and thrust of the screw can be increased at higher speeds without increase of propeller diameter.

And in any case it is most likely that the power expended in lifting will be very much greater than that expended in propelling.

Judging from the great diameters of propellers found by calculations, it is safe to say that multiple propellers will be used, aggregating in area, equal to the large ones, probably six lifting propellers to one propelling propeller.

There is, however, no getting over the fact that the lifting propeller must either be of large size or, if of small size, waste power, and we must arrive at the price we can pay, in power, for reduction in propeller diameters and weights.

Propellers for propelling are not so bad, the required thrust is not likely to be great, and probably we can afford a screw slip S of a value equal to the airship's speed V.

These calculations are set out as fundamental calculations. They are intended to show the principles of propulsion in a fluid, and as clear indications of the necessity for large propellers due to small weight of air per cubic foot, and the limit to the real slip of the screw propeller.

In practice the engineer will find modification necessary in order to compromise with the antagonistic conditions. But one thing is certain, that no aëroplane can be of the least assistance in reducing the dimensions of propellers. Upon the prime mover and its propeller comes all the work to be done both in lifting the weight against gravity g and in propelling against air resistance R, and, considering first that large propellers are absolutely necessary, it is very doubtful if an engineer would add equally large or larger aëroplanes, to split the thrust into a horizontal and a vertical component without some very good reason. No such reason is apparent at present, except one which may or may not be practicable, and that is, that the aëroplane would act as a parachute in case of engine stoppages. If aëroplanes can fill the double purpose of splitting the thrust into lifting and propelling components, when in motion, and as a parachute when the thrust ceases, they may justify their existence. This point is very doubtful and requires experiment to clear it up, tests made by thoroughly well calculated and designed propellers and planes.

But there is another objection to the use of one propeller only and splitting planes for producing two components.

The one component which sustains the weight in the air must be constant, both in direction and in amount of thrust, while the other, the one which propels the airship, is variable, both in direction and amount of thrust.

In fact, the latter may be negative or zero, or a maximum from time to time, and must be thoroughly under control.

Now, most engineers would rather not try to combine a variable force with a constant one; it is impossible to keep one constant and vary the other by one instrument without destroying stability or reducing it to a dangerous amount.

An aëroplane could not vary the one component without varying the other, unless at the same time the engine-power were varied, and the whole operation would have to be carried out with the greatest care and nicety, and with every change of wind pressure, and also in ascending or descending—otherwise disaster.

In mechanics it is considered best to separate constant forces from variables, so that the variables can be dealt with separately without upsetting the constancy of the constants. For these reasons it appears that the aëroplane does not offer such an easy solution of the practical engineering problems as its devotees imagine.

The aëroplane has its uses, but while it contributes nothing to the lifting of the airship nor to its propulsion, it adds resistance to motion, and weight to be lifted. Therefore to justify its employment it must have other useful functions besides splitting up the power of the propeller into two forces, one constant and the other variable. The aëroplane may be used in steering and in balancing, and may be, in acting as a parachute, useful, if that is possible.

However, no aëroplane machine has ever remained long enough afloat for us to see whether it would be useful in these respects, and until we can command a ship that will go up and stay up long enough to make tests of the aëroplanes, propellers, and safety apparatus, and other things, we cannot place true values on the aëroplane in any function whatever.

One encouraging fact remains, and that is that to propel an airship through air requires but small power; once get the ship afloat and propulsion is an easy matter.

In any case if an aëroplane is used the

thrust required for sustaining the weight, and propelling, must be provided for in the engine and propellers just the same as if no aëroplanes were used.

These considerations have led me to the conclusion that aëroplanes offer no advantages, so that propellers for weight-carrying should be provided, and separate propellers for propelling.

It has been reported that attempts have been made to fly a machine with a 100-horse power engine on a 6.75 foot propeller. It cannot be possible that any calculations at all were made in such a case. A 7-foot propeller in air is of a very small power; even at the non-economical speed of S = 32 feet it would not lift more than 100 lbs., and take 3-horse power actually delivered at the propeller blades; probably a 6 brake-horse-power would be the biggest engine a 7-foot propeller would accommodate.

The problem, like all others worth solving, bristles with difficulties, but none of them are beyond the possibilities of engineering. Invention will supply designs; mathematics will take care of the dimensions, and modern tools and materials are capable of the constructional work. If experiments are worth making at all, they must be thorough in every respect, the object of the experiment must be clearly defined so that the results may be gauged, and every detail should be subjected to scientific and mathematical analysis before construction begins. Only on a methodical system like that can sure progress be made.

In these few examples of the working of propellers it is hoped by the author that the true principles of air propellers can be clearly seen, and their dimensions made attainable.

Some engineers have other views regarding the sternward-driven column of air, but all of them in the end arrive at the same results. Their formulæ, based on their different theories when used for actual dimensional calculations, generally lead to the same, propeller speeds, pitch, diameter, and efficiencies, or absolute failure of the screws. In the latter case the formulæ is altered to meet the cause of failure and re-altered until the old formulæ of Professor Rankine is returned to again.

Again, we can study the reaction of an air column in motion very well, in a first-class modern windmill, with well-designed blades properly curved. In this case an air column of A area and speed V strikes the blades and is deviated, producing motion of the wheel with a pressure which can easily be calculated from $A.V^2$. It is exactly the converse of the airship propeller screw; in the one case the air acting on the blades produces power proportional to $A.V.^2$ and in the other the blades acting on the air produces motion in a column of air with an area A and a speed V absorbing power proportional to V^2. In developing wind engines, engineers had to face the necessity for large blade areas and aëronautical engineers will not escape from the same necessities in airship propellers.

Foreign Aëronautical Publications.

(In this list a selection of some of the more notable articles is only given.)

L'AÉRONAUTE (Paris).

October.—Study of a helicoidal Sustainer or Propeller.—Ascent of the balloon "Cirro."

L'AÉROPHILE (Paris).

October.—The Wellman Dirigible; its voyage towards the North Pole.—The Wellman Expedition; mathematical considerations.—The English Military Balloon.—Historical Notes on Aëroplanes, by Victor Tatin.

November.—Trials of the Farman Flying Machine.—Birds, Aëroplanes, and Air Resistance, by Victor Tatin.—Santos Dumont's No. 19.—The Automatic Equilibrium of Aëroplanes.

December.—The Esnault-Pelterie Flying Machine.—The voyage of the "Mammoth."—The steering of an Aëroplane.—The work done by the "Patrie" during the autumn.

ILLUSTRIERTE AERONAUTISCHE MITTEILUNGEN.

October and November.—Aërological Expedition to Iceland.—New experiments with the Zeppelin Airship.—The value of Flying Model Competitions.—The Aëronautical Competition at Brussels.—The German Aëronautical Convention.

December.—The Wellman Expedition, 1907.—Further experiments with the Zeppelin Airship.—The Farman and Pelterie Flying Machines.—The Wels Glider.—The Aëronautical work of Mons. Bleriot.

December.—Special (Gordon-Bennett).—The Gordon-Bennett Race.—The trip of the Pommern (winner).—The provision for Aëronautical Science in the Imperial German Budget.—Automatic Stability.

WIENER LUFTSHIFFER ZEITUNG (Vienna).

October.—The Wellman Expedition.—The Zeppelin Airship.—The Von-Parseval Balloon.—The British Military Airship.—Elements of Practical Aëronautics.—Airships at the Peace Congress.—The Convention at Brussels.

November.—The Gordon-Bennett Race.—Further successes of the Zeppelin Balloon.—The British Military Airship.—The Wellman Expedition.—The Wels Glider.

December.—The Gordon-Bennett Race.—Trip from Basle to London.—Reliability trials of Dirigible Balloons.—New record trip of the "Patrie."—Chanute on Flying Machines.—Lecture on Motors, by Major Hoernes.

LA REVUE DE L'AVIATION.

October.—Capt. Ferber's experiences in a 6-h.p. machine.—A history of Aviation.—The Bregnet and Richet Machine.—Aviation in Bohemia.—The Wels Machine.—A Treatise on Aviation.

November.—On the weight of Flying Machines.—The Esnault-Pelterie Motor; the efficiency of aërial screws.—A Treatise on Aviation.

BOLLETTINO DELLA SOCIETA ITALIANA (Rome).

October. — Proceedings of the International Aëronautical Federation, 1907. — The British Dirigible Balloon —Zeppelin's Nos. III. and IV. Balloons.—The Parseval.

November.—The Autumn work of the "Patrie."—The "Nulli Secundus."—The Baldwin Dirigible Balloon.—Scientific Notes; the shape of balloon envelopes, etc.

December—Rain and Aëronautical Ascensions.—Researches on Atmospheric Electricity.—Aëroplanes.—The "Patrie"—"Nulli Secundus" II. and III.—International Commission for Aëronautical Maps.—Scientific Notes.

Applications for Patents.

(*Made in October, November, and December.*)

The following list of Applications for Patents connected with Aëronautics has been specially compiled for the AËRONAUTICAL JOURNAL by Messrs. BROMHEAD & Co, Patent Agents, 33, Cannon Street, London, E.C.

OCTOBER.

21268. September 25th. J. BELLAMY. Improved air ship.

21290. September 25th. T. CLARKE.

21509. September 28th. A. WORSWICK. Improved aeroplane.

21615. September 30th. W. LOVE. Improved method of propelling, lifting, and steering flying machines, air ships and aeroplanes, and the like.

21923. October 4th. C. A. CHAPPELL. Improvements in flying machines.

22075. October 7th. V. SELJAK and R. EBENSPANGER. Improvements in dirigible air ships.

22146. October 8th. J. WESTAWAY. Improvements in aeronautical propellers.

22147. October 8th. J. WESTAWAY. Improvements in air ships.

22250. October 9th. F. E. JACKSON. Kites, air ships, and the like.

22273. October 9th. C. J. DAVIES. New or improved aerial machine.

22464 October 11th. W. H. PRESTWICH. Improved dirigible balloon.

22697. October 15th. G. R. LAWRENCE. Aerial photographing apparatus.

22838. October 11th. W. LOVELL and M. WALLIS. New or improved navigable balloon.

23121. October 19th. V. BAINES. Improvements in or relating to aerial machines.

9413a. October 23rd. F. W. LANCHESTR. Improvements in driving mechanism for aeronautical or marine propellers. (Date applied for under rule 5 of the Patents' Rules, 1905, April 23rd, 1907)

23254. October 21st. W. O'NEILL. Vacuum ship for navigating the air.

23281. October 22nd. A. NARLIAN. Improvements upon balloons or air ships, or other navigating machines in reference to their dirigibility.

23307. October 22nd. S. DAY. Improvements in flying or air cars.

23459. October 24th. J. RAGGETT. Improvements in aeroplanes,

23553. October 24th. P. WATSON. Flying machines.

NOVEMBER.

24247. November 2nd. D. SCOTT and W. SCOTT. Improvements in flying machines.

24418. November 5th. J. DUNCAN. Improvements in flying machines.

24535. November 5th. B. BROWN. Improvements in raising and propelling aerial machines or air ships.

24537. November 5th. A. WOLFMULLER. Steering device for flying machines. (Date applied for under Patents' Act, 1901, 5th November, 1906, being date of application in Germany.)

24673. November 7th. J. PASSATT. Improvements in apparatus for aerial navigation.

25518. November 18th. G. ANTONI and W. ANTONI. Improvements in or relating to flying machines.

25574. November 19th. W. SUHR. Improved air ship on the "heavier-than-air" principle.

25854. November 22nd. M. VINNING. Improvements relating to ballast of balloons, air ships, and the like.

25926. November 22nd. M. DORWALD. Device for driving large propellers by means of high speed motors.

26000. November 23rd. F. HENNIBIQUE. Improvements in aerostatic apparatus.

DECEMBER.

26089. November 25th. H. BIDELL. **Improvements in and relating to means for operating on fluids to obtain a reacting force particularly applicable to flying machines.**

26884. December 5th. M. BJELOVUCIC. **Improvements in propellers for water and aerostatic vessels.**

27008. December 6th. J. BIRKETT. **Improvements in and relating to aeroplanes and like machines.**

27178. December 9th. J. HUMPHREYS. **Improved method of propulsion of air vessels and the like.**

27179. December 9th. J. HUMPHREYS. **Improvements in aeroplanes.**

27180. December 9th. J. HUMPHREYS. **Improved method controlling the altitude of balloons.**

27221. December 9th. S. FADDA and D. LORENZO. **Improvements in air ships.**

27250. December 10th. J. FRASER. **Improvements in and relating to propelling and lifting devices and the like for air and water navigation.**

27405. December 11th. J. WEISS. **Improvements in or relating to launching ways for aeroplanes.**

27408. December 11th. J. STRAKA. **Improvements in or relating to steerable air ships.**

27464. December 12th. M. GIBSON. **Improvements in flying machines.**

27686. December 16th. J. GARSED. **Improvements in aerial machines and in the method of and means employed for propelling and steering same.**

27693. December 16th. T. MEACOCK. **Improvements in and relating to means for the propulsion and steering of flying machines.**

27805. December 17. B. CONNOLLY. **Improvements in and relating to aerial machines.**

28034. December 19th. R. E. PELTERIE. **Improvements in aeroplanes.** (Date applied for under Patents' Act, 1901, 22nd December, 1906, being date of application in Germany.

28078. December 20th. A DAVIS. **Improved means for controlling and manœuvring dirigible balloons.**

28145. December 20th. E. ATRENS. **Improvements relating to kite flying.**

28590. December 30th. F. CAPONE. **Improvements in aeroplanes.**